

Chapter 1: The Conceit of Hindsight

"History doesn't repeat itself, but it rhymes"

- Mark Twain

"History repeats itself; that's one of the things that's wrong with history."

- Clarence Darrow

History has been described as one damn thing after another. The remark can be seen as a salutary warning against a pair of temptations but, duly warned, I shall cautiously flirt with both. First, the historian is tempted to scour the past for patterns that repeat themselves; or at least, following Mark Twain, to seek reason and rhyme for everything. This appetite for pattern affronts those who insist that, as Mark Twain will also be found to have said, "History is usually a random, messy affair", going nowhere and following no rules. The second connected temptation is the vanity of the present: of seeing the past as aimed at our own time, as though the characters in history's play had nothing better to do with their lives than foreshadow us.

Under names that need not trouble us, these are live issues in human history and they arise with greater force, and no greater agreement, on the longer time scale of evolution. Evolutionary history can be represented as one damn species after another. But many biologists will join me in finding this an impoverished view. Look at evolution that way and you miss most of what matters. Evolution rhymes, patterns recur. And this doesn't just happen to be so. It is so for well understood reasons: Darwinian reasons mostly, for biology, unlike human history or even physics, already has its grand unifying theory, accepted by all informed practitioners, though in varying versions and interpretations. In writing evolutionary history I do not shrink from seeking patterns and principles, but I try to be careful about it.

What of the second temptation, the conceit of hindsight, the idea that the past works to deliver our particular present? The late

Stephen Jay Gould rightly pointed out that a dominant icon of evolution in popular mythology, a caricature almost as ubiquitous as lemmings jumping over cliffs (that myth is false too), is a shambling file of simian ancestors, rising progressively in the wake of the erect, striding, majestic figure of *Homo sapiens sapiens*: man as evolution's last word (and in this context it always is man rather than woman); man as what the whole enterprise is pointing towards; man as a magnet, drawing evolution from the past towards his eminence.

There is a physicist's version which is less obviously vainglorious and which I should mention in passing. This is the 'anthropic' notion that the very laws of physics themselves, or the fundamental constants of the universe, are a carefully tuned put-up job, calculated to bring humanity eventually into existence. It is not necessarily founded on vanity. It doesn't have to mean that the universe was deliberately made in order that we should exist. It need mean only that we are here, and we could not be in a universe that lacked the capability of producing us. As physicists have pointed out, it is no accident that we see stars in our sky, for stars are a necessary part of any universe capable of generating us. Again, this does not imply that stars exist in order to make us. It is just that without stars there would be no atoms heavier than lithium in the periodic table, and a chemistry of only three elements is too impoverished to support life. Seeing is the kind of activity that can go on only in the kind of universe where what you see is stars.

But there is a little more that needs to be said. Granted the trivial fact that our presence requires a universe capable of producing us, the existence of such a potent universe may still seem tantalisingly improbable. Depending upon their assumptions, physicists may reckon that the set of possible universes vastly outnumbers that subset whose laws and constants allowed physics to mature, via stars into chemistry and via planets into biology. To some, this means that the laws and constants must have been deliberately

premeditated from the start (although it baffles me why anybody regards this as an explanation for anything, given that the problem so swiftly regresses to the larger one of explaining the existence of the equally fine-tuned and improbable Premeditator).

Other physicists are less confident that the laws and constants were free to vary in the first place. When I was little it was not obvious to me why 5 times 8 had to give the same result as 8 times 5. I accepted it as one of those facts that grownups assert. Only later did I understand, perhaps through visualizing areas of rectangles, why such pairs of multiplications are not free to vary independently of one another. We understand that the circumference and the diameter of a circle are not independent, otherwise we might feel tempted to postulate a plethora of possible universes, each with a different value of π . Perhaps, argue some physicists such as the Nobel Prize-winning theorist Steven Weinberg, the fundamental constants of the universe, which at present we treat as independent of one another, will in some Grand Unified fullness of time be understood to have fewer degrees of freedom than we now imagine. Maybe there is only one way for a universe to be. That would undermine the appearance of anthropic coincidence.

Other physicists, including Sir Martin Rees the present Astronomer Royal, accept that there is a real coincidence in need of explanation, and explain it by postulating many actual universes existing in parallel, mutually incommunicado, each with its own set of laws and constants^[1]. Obviously we, who find ourselves reflecting upon such things, must be in one of those universes, however rare, whose laws and constants are capable of evolving us.

The theoretical physicist Lee Smolin added an ingenious Darwinian spin which reduces the apparent statistical improbability of our existence. In Smolin's model, universes give birth to daughter universes, which vary in their laws and constants. Daughter

universes are born in black holes produced by a parent universe and they inherit its laws and constants but with some possibility of small random change - 'mutation'. Those daughter universes that have what it takes to reproduce (last long enough to make black holes, for instance) are, of course, the universes that pass on their laws and constants to their daughters. Stars are precursors to black holes which, in the Smolin model, are the birth events. So universes that have what it takes to make stars are favoured in this cosmic Darwinism. The properties that furnish this gift to the future are the self-same properties that incidentally lead to the manufacture of large atoms, including vital carbon atoms. Not only do we live in a universe that is capable of producing life. Successive generations of universes progressively evolve to become increasingly the sort of universe that, as a byproduct, is capable of producing life.

The logic of the Smolin theory is bound to appeal to a Darwinian, indeed to anyone of imagination, but as for the physics I am not qualified to judge. I cannot find a physicist to condemn the theory as definitely wrong. The most negative thing they will say is that it is superfluous. Some, as we saw, dream of a final theory in whose light the alleged fine-tuning of the universe will turn out to be a delusion anyway. Nothing we know rules out Smolin's theory, and he claims for it the merit - which scientists rate more highly than many laymen appreciate - of testability. His book is *The Life of the Cosmos* and I recommend it.

But that was a digression about the physicist's version of the conceit of hindsight. The biologist's version is easier to dismiss since Darwin, though harder before him, and it is our concern here. Biological evolution has no privileged line of descent and no designated end. Evolution has reached many millions of interim ends (the number of surviving species at the time of observation), and there is no reason other than vanity - human vanity as it happens, since we are doing the talking - to designate any one as more privileged or climactic

than

any

other.

This doesn't mean, as I shall continue to argue, that there is a total dearth of reasons or rhymes in evolutionary history. I believe there are recurring patterns. I also believe, though this is more controversial today than it once was, that there are senses in which evolution may be said to be directional, progressive and even predictable. But progress is emphatically not the same thing as progress towards humanity, and we must live with a weak and unflattering sense of predictable. The historian must beware of stringing together a narrative that seems, even to the smallest degree, to be homing in on a human climax.

A book in my possession (in the main a good book, so I shall not name and shame it) provides an example. It is comparing *Homo habilis* (a human species, probably ancestral to us) with its predecessors the Australopithecines[2]. What the book says is that *Homo habilis* was "considerably more evolved than the Australopithecines". More evolved? What can this mean but that evolution is moving in some pre-specified direction? The book leaves us in no doubt of what the presumed direction is. "The first signs of a chin are apparent." "First" encourages us to expect second and third signs, towards a "complete" human chin. "The teeth start to resemble ours . . ." As if those teeth were the way they were, not because it suited the *habilis* diet but because they were embarking upon the road towards becoming our teeth. The passage ends with a telltale remark about a later species of extinct human, *Homo erectus*: "Although their faces are still different from ours, they have a much more human look in their eyes. They are like sculptures in the making, 'unfinished' works." In the making? Unfinished? Only in the unwisdom of hindsight. In excuse of that book it is probably true that, were we to meet a *Homo erectus* face to face, it might well look to our eyes like an unfinished sculpture in the making. But that is only because we are looking with human hindsight. A living creature is

always in the business of surviving in its own environment. It is never unfinished – or, in another sense, always unfinished. So, presumably, are we.

The conceit of hindsight tempts us at other stages in our history. From our human point of view, the emergence of our remote fish ancestors from sea to land was a momentous step, an evolutionary rite of passage. It was undertaken in the Devonian period by lobe-finned fishes a bit like modern lungfish. We look at fossils of the period with a pardonable desire to gaze upon our forebears, and are seduced by a knowledge of what came later: drawn into seeing these Devonian fishes as ‘half way’ towards becoming land animals; everything about them earnestly transitional, bound into an epic quest to invade the land and initiate the next big phase of evolution. That is not the way it was at the time. Those Devonian fishes had a living to earn. They were not on a mission to evolve, not on a quest towards the distant future. An otherwise excellent book about vertebrate evolution contains the following sentence about fish which “ventured out of the water on to the land at the end of the Devonian period and jumped the gap, so to speak, from one vertebrate class to another to become the first amphibians . . .”

The ‘gap’ comes from hindsight. There was nothing resembling a gap at the time, and the ‘classes’ which we now recognize were no more separate, in those days, than two species. As we shall see again, ‘jumping gaps’ is not what evolution does.

It makes no more sense (and no less) to aim our historical narrative towards *Homo sapiens* than towards any other modern species – *Octopus vulgaris*, say, or *Panthera leo* or *Sequoia sempervirens*. A historically minded swift, understandably proud of flight as self-evidently the premier accomplishment of life, will regard swiftkind – those spectacular flying machines with their swept-back wings, who stay aloft for a year at a time and even copulate in free flight – as the acme of evolutionary progress. To build on a fancy of Steven Pinker, if elephants could write history they might portray tapirs, elephant

shrews, elephant seals and proboscis monkeys as tentative beginners along the main trunk road of evolution, taking the first fumbling steps but each – for some reason – never quite making it: so near yet so far. Elephant astronomers might wonder whether, on some other world, there exist alien life forms that have crossed the nasal rubicon and taken the final leap to full proboscitude.

We are not swifts nor elephants, we are people. As we wander in imagination through some long dead epoch, it is humanly natural to reserve a special warmth and curiosity for whichever otherwise ordinary species in that ancient landscape is our ancestor (it is an intriguingly unfamiliar thought that there is always one such species). It is hard to deny our human temptation to see this one species as ‘on the main line’ of evolution, the others as supporting cast, walk-on parts, sidelined cameos. Without succumbing to that error, there is one way to indulge a legitimate human-centrism while respecting historical propriety. That way is to do our history backwards, and it is the way of this book.

Backward chronology in search of ancestors really can sensibly aim toward a single distant target. The distant target is the grand ancestor of all life, and we can’t help converging upon it no matter where we start – elephant or eagle, swift or salmonella, wellingtonia or woman. Backward chronology and forward chronology are each good for different purposes. Go backwards and, no matter where you start, you end up celebrating the unity of life. Go forwards and you extol diversity. It works on small timescales as well as large. The forward chronology of the mammals, within their large but still limited timescale, is a story of branching diversification, uncovering the richness of that group of hairy warmbloods. Backward chronology, taking any modern mammal as our starting point, will always converge upon the same unique ur-mammal; shadowy, insectivorous, nocturnal contemporary of the dinosaurs. This is a local convergence. A yet more local one converges on the most

recent ancestor of all rodents, who lived somewhere around the time the dinosaurs went extinct. More local still is the backward convergence of all apes (including humans) on their shared ancestor, who lived about 18 million years ago). On a larger scale, there is a comparable convergence to be found if we work backwards from any vertebrate, an even larger convergence working backwards from any animal to the ancestor of all animals. The largest convergence of all takes us from any modern creature – animal, plant, fungus or bacterium – back to the universal progenitor of all surviving organisms, probably resembling some kind of bacterium.

I used 'convergence' in the last paragraph, but I really want to reserve that word for a completely different meaning in forward chronology. So for the present purpose I shall substitute 'confluence' or, for reasons which will make sense in a moment, 'rendezvous'. I could have used 'coalescence', except that, as we shall see in Eve's Tale, geneticists have already adopted it in a more precise sense, similar to my 'confluence' but concentrating on genes rather than species.

In a backward chronology, the ancestors of any set of species must eventually meet at a particular geological moment. Their point of rendezvous is the last common ancestor that they all share, what I shall call their 'Concestor': the focal rodent or the focal mammal or the focal vertebrate, say. The oldest concestor is the grand ancestor of all surviving life, probably something like a bacterium.

We can be very sure there really is a single concestor of all surviving life forms on this planet. The evidence is that all surviving creatures that have ever been examined share (exactly in most cases, almost exactly in the rest) the same genetic code; and the genetic code is too detailed, in arbitrary aspects of its complexity, to have been invented twice. Although not every species has been examined, we already have enough coverage to be pretty certain that no surprises

- alas - await us. If we now were to discover a life form sufficiently alien to have a completely different genetic code, it would be the most exciting biological discovery in my adult lifetime, whether it lives on this planet or another. As things stand, it appears that all known life forms can be traced to a single ancestor which lived more than three billion years ago. If there were other, independent origins of life, they have left no descendants that we have discovered. And if new ones arose now they would swiftly be eaten, probably by bacteria.

The grand confluence of all surviving life is not the same thing as the origin of life itself. This is because all surviving species presumably share a concestor who lived after the origin of life: anything else would be an unlikely coincidence, for it would suggest that the original life form immediately branched and more than one of its branches survive to this day. Current textbook orthodoxy dates the oldest bacterial fossils at about 3.5 billion years ago, so the origin of life must at least be earlier than that. If we accept a recent disputation of these apparently ancient fossils, our dating of the origin of life might be a bit more recent. The grand confluence - the last common ancestor of all surviving creatures - could predate the oldest fossils (it didn't fossilise) or it could have lived a billion years later (all but one of the other lineages went extinct).

Given that all backward chronologies, no matter where they start, culminate in the one grand confluence, we can legitimately indulge our human preoccupation and concentrate upon the single line of our own ancestors. Instead of treating evolution as aimed towards us, we choose modern *Homo sapiens* as our arbitrary, but forgivably preferred, starting point for a reverse chronology. We choose this route, out of all possible routes to the past, because we are curious about our own great grancestors. At the same time, although we need not follow them in detail, we shall not forget that there are other historians, animals and plants belonging to other species, who

are independently walking backwards from their separate starting points, on separate pilgrimages to visit their own ancestors, including eventually the ones they share with us. If we retrace our own ancestral steps, we shall inevitably meet these other pilgrims and join forces with them in a definite order, the order in which their lineages rendezvous with ours, the order of ever more inclusive cousinship.

Pilgrimages? Join forces with pilgrims? Yes, why not? Pilgrimage is a striking way to think about our journey to the past. This book will be cast in the form of a gigantic pilgrimage from the present to the past. All roads lead to the origin of life. But because we are human, the path we shall follow will be that of our own ancestors. It will be a human pilgrimage to discover human ancestors. As we go, we shall greet other pilgrims who will join us in strict order, as we reach the common ancestors we share with them.

For example, the first fellow pilgrims we shall greet, some 5 million years ago, deep in Africa where Stanley memorably greeted Livingstone, are the chimpanzees. The chimpanzee and bonobo pilgrims will already have joined forces with each other 'before' we greet them. And here we have a little linguistic problem which I must raise at the outset, before it dogs us any further. I placed 'before' in inverted commas because it could confuse. I used it to mean before in the backwards sense - 'before, in the course of the pilgrimage to the past'. But that of course means *after* in the chronological sense, the exact opposite meaning! My guess is that no reader was confused in this particular case, but there will be other instances where the reader's patience may be tried to irritation. While writing this book I tried the experiment of coining a new preposition, tailored to the peculiar needs of a backward historian. But it wasn't entirely successful. Instead, I shall adopt the convention of 'before' in inverted commas. When you see 'before', remember that it really means after! When you see before, it really means before. And the

same for 'after' and after, *mutatis mutandis*.

The next pilgrims with whom we shall rendezvous as we push back along our journey are gorillas, then orang utans (quite a lot deeper into the past, and probably no longer in Africa). Next we shall greet gibbons, then Old World Monkeys, then New World Monkeys, then various other groups of mammals . . . and so on until eventually all the pilgrims of life are marching together in one single backward quest for the origin of life itself. As we push on back, there will come a time where it is no longer meaningful to name the continent in which rendezvous take place: the map of the world was so different, because of the remarkable phenomenon of plate tectonics. And further back still, all rendezvous take place in the sea.

By convention, I shall acknowledge as fellow pilgrims only those who set off from the present at the same time as we do. It is then a rather surprising fact that we human pilgrims pass only about forty rendezvous points in all, until we hit the origin of life itself. At each of these numbered rendezvous points we shall find one particular shared ancestor, the Concestor, which will bear the same labelling number as the Rendezvous. For example, Concestor 2, whom we meet at Rendezvous 2, is the most recent common ancestor of gorillas on the one hand and {humans + {chimpanzees + bonobos}} on the other. Concestor 3 is the most recent common ancestor of orang utans and {{humans + {chimpanzees + bonobos}} + gorillas}. Concestor 39 is the grand ancestor of all surviving life forms. Concestor 0 is a special case, the most recent ancestor of all surviving humans.

We shall be pilgrims, then, sharing fellowship ever more inclusively with other pilgrim bands, which also have been swelling on their own way to their rendezvous with us. After each meeting, we continue together on the high road back to our shared Hadean goal, our 'Canterbury'. There are other literary allusions, of course, and I

almost made Bunyan my model and *Pilgrim's Regress* my title. But it was to Chaucer's *Canterbury Tales* that I and my research assistant Yan Wong kept returning in our discussions, and it seemed increasingly natural to think Chaucer throughout this book.

Unlike (most of) Chaucer's pilgrims, mine do not all set out together, although they do set off at the same time, the present. These pilgrims aim towards their ancient Canterbury from different starting points, joining our human pilgrimage at various rendezvous along the road. In this respect, my pilgrims are unlike those who gathered in London's Tabard Inn. Mine are more like the sinister canon and his understandably disloyal yeoman, who joined Chaucer's pilgrims at Boughton-under-Blee, five miles outside Canterbury. Following Chaucer's lead, my pilgrims, which are all the different species of living creature, will have the opportunity to tell tales along the way to their Canterbury which is the origin of life. It is these tales that form the main substance of this book.

Dead men tell no tales, and extinct creatures such as trilobites are deemed not to be pilgrims capable of telling them. Since we human pilgrims are directly seeking our own ancestors, however, recent fossils that might actually *be* our ancestors are deemed members of our human pilgrimage and we shall hear tales from some of these 'shadow pilgrims'.

I decided it would be twee to let my animal and plant tale-tellers speak in the first person singular and I shall not do so. Save for occasional asides and prefatory remarks, Chaucer's pilgrims don't either. Many of Chaucer's Tales have their own Prologue, and some have an Epilogue too, all written in Chaucer's own voice as narrator of the pilgrimage. In place of prologues, I will take care to introduce the joining band of pilgrims at each rendezvous. Often one or more of the joining pilgrims will have an appropriate tale to tell and, as with Chaucer, an epilogue may serve as a bridge from one tale to the

next.

Before his Tales begin, Chaucer has a long General Prologue in which he sets out his cast list: the professions and in some cases the names of the pilgrims who are about to set off from the tavern. The jovial Host offers to be their guide, and encourages them to tell tales on the journey to Canterbury, to while away the hours. Instead, in my role as host I shall use the General Prologue for some preparatory remarks about methods and problems of reconstructing evolutionary history, which must be faced and solved whether we do our history backwards or forwards.

Then we shall embark on our backwards history itself. Although we shall concentrate on our own ancestors, noting other creatures usually only when they join us, we shall from time to time look up from our road and remind ourselves that there are other pilgrims on their own independent routes to our ultimate destination. The numbered Rendezvous milestones, plus a few intermediate markers necessary to consolidate the chronology, will provide the scaffolding for our journey. Each will mark a new chapter, where we halt to take stock of our pilgrimage, and maybe listen to a tale or two. On rare occasions, something important happens in the world around us, and then our pilgrims may pause briefly to reflect on it. But, for the most part, we shall mark our progress to the dawn of life by the measure of those forty natural milestones, the rendezvous that swell our pilgrimage.

[1] This 'many universes' idea is not to be confused (though it often is) with Hugh Everett's 'many worlds' interpretation of quantum theory, brilliantly advocated by David Deutsch in *The Fabric of Reality*. The resemblance between the two theories is superficial and meaningless. Both theories could be true, or neither, or one, or the other. They were proposed to answer completely different problems.

In the Everett/Deutsch theory, the different universes don't differ in their fundamental constants. But it is the entire point of the theory we are here considering that the different universes have different fundamental constants.

[2] The laws of zoological nomenclature follow strict precedence, and I fear there is no hope of changing the name *Australopithecus* to something less confusing to the contemporary majority who lack a classical education. It has nothing to do with Australia. No member of the genus has ever been found outside Africa. Australo simply means southern. Australia is the great southern continent, the Aurora australis is the *southern* equivalent of the Aurora borealis (boreal means northern), and *Australopithecus* was first found in *south* Africa, in the person of the Taung child.